

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



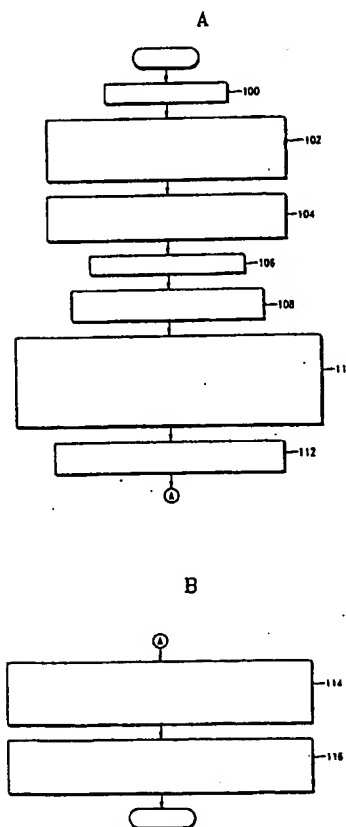
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : G06T 1/00, 7/60	A1	(11) International Publication Number: WO 00/46749 (43) International Publication Date: 10 August 2000 (10.08.00)
(21) International Application Number: PCT/KR00/00090 (22) International Filing Date: 3 February 2000 (03.02.00) (30) Priority Data: 60/118,741 5 February 1999 (05.02.99) US (71) Applicants: SAMSUNG ELECTRONICS CO., LTD. [KR/KR]; 416, Maetan-dong, Paldal-gu, Suwon-city, Kyungki-do 442-373 (KR). THE REGENTS OF THE UNIVERSITY OF CALIFORNIA [US/US]; 12th floor, 1111 Franklin Avenue, Oakland, CA 94607-5200 (US). (72) Inventors: SHIN, Hyun, Doo; 510-1302 Mujigae Maeul Cheonggu Apt., 221 Kumi-dong, Bundang-gu, Sung- nam-city, Kyungki-do 463-500 (KR). CHOI, Yang, Lim; 102-1112 Wooman Sunkyung Apt., 105 Wooman-dong, Paldal-gu, Kyungki-do 442-190 (KR). DENG, Yining; Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106-9560 (US). MANJUNATH, B., S.; Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106-9560 (US). (74) Agent: LEE, Young, Pil; The Cheonghwa Building, 1571-18 Seocho-dong, Seocho-gu, Seoul 137-073 (KR).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: **COLOR IMAGE PROCESSING METHOD AND APPARATUS THEREOF**

(57) Abstract

A color image processing method and apparatus thereof are provided. The color image processing method includes the steps of (a) sorting image pixels according to the color distance between the image pixels and a central pixel, (b) grouping the sorted pixels into groups in which the difference in the intragroup color distance/is minimum and the difference in the intergroup color difference is maximum, and (c) performing filtering by replacing a central pixel-value with a predetermined pixel value determined by pixel values of pixels in the groups. The color image processing method can reduce the generation of edge blurring of the image in removing impulse noise from an image and filtering the same.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

COLOR IMAGE PROCESSING METHOD AND APPARATUS THEREOF

Technical Field

The present invention relates to an image processing method, and more particularly, to a color image processing method which is a pre-processing method required for retrieving a color feature descriptor used in indexing and searching a color image.

Background Art

10 In object-based digital image compression standards such as MPEG-7, color feature descriptors for indexing and searching color images are defined. A color feature descriptor is retrieved from an input image.

In the color image processing method, in order to retrieve a color feature descriptor, an input image is segmented into a plurality of regions, quantized color
15 vectors for the segmented regions are obtained, and then the color feature descriptor of a pertinent region is determined using the quantized color vectors. However, noise components may exist in the image. Also, good color quantization is important in accurately representing color information in the image. Thus, pre-processing such as filtering or noise removal is necessarily performed before quantization.

20 Conventionally, in order to remove noise from an image, filtering methods such as vector median filtering or vector directional filtering have been employed.

However, since filtering method used in conventional color image processing methods are uniformly applied to an image, non-noisy pixels may be modified, which causes edge blurring in the original image.

25

Disclosure of the Invention

To solve the above problem, it is an objective of the present invention to provide a color image processing method and apparatus, by which filtering can be
30 performed without edge blurring of the color image and noise in the color image can be eliminated, the method being a pre-processing method required for retrieving a

color feature descriptor for indexing and searching the color image.

It is another object of the present invention to provide a computer readable medium having a program executable by a computer to perform the color image processing method.

- 5 A feature of the present invention is embodied by a color image processing method includes the steps of (a) sorting image pixels according to the color distance between the image pixels and a central pixel, (b) grouping the sorted pixels into groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum, and (c) performing
10 filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.

The color image processing method may further include the step of defining a window having a predetermined size within an input color image, wherein the image pixels are pixels within the window.

- 15 Before the step (b), the method preferably further includes the step of removing pixels having a difference in color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.

- The predetermined number is preferably less than or equal to $L/2$, in which
20 L is a predetermined positive number indicating the size of an $L \times L$ window.

Before the step (b), the method preferably further includes the step of removing pixels having a difference in color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.

- 25 Also, the step (b) may include grouping the sorted pixels using a function based on a Fisher's discriminant estimation method.

- The step (b) may include the sub-steps of (b-1) setting a first group consisting of 0th through $(i-1)$ th pixels, and a second group consisting of i th through K th pixels, wherein i is an integer from 0 through K and $K=L^2-1$, (b-2) obtaining the
30 respective averages of the color distance differences for pixels of the first and second groups by the following Expressions:

$$a_1(i) = \frac{1}{i} \sum_{j=0}^{i-1} d_j(n) \quad \text{and} \quad a_2(i) = \frac{1}{K+1-i} \sum_{j=i}^K d_j(n) \quad . \text{(b-3) obtaining the}$$

respective variances of the color distance differences for pixels of the first and second groups are obtained by the following Expressions:

$$S_1^2(i) = \sum_{j=0}^{i-1} |d_j(n) - a_1(i)|^2 \quad \text{and} \quad S_2^2(i) = \sum_{j=i}^K |d_j(n) - a_2(i)|^2 \quad , \text{(b-4)}$$

- 5 calculating a value $J(i)$ by the following Expression, using the obtained average and variance:

$$J(i) = \frac{|a_1(i) - a_2(i)|^2}{S_1^2(i) + S_2^2(i)} \quad . \text{and (b-5) obtaining the value of } i \text{ which makes}$$

$J(i)$ maximum by the following Expression:

$$m(n) = \max_i \{J(i)\} \quad , \text{and selecting pixels ranging from a pixel having a}$$

- 10 small color distance to a pixel having the obtained value of i to determine the same as a peer group $P(n)$.

Also, after the step (b-5), the method may further include the steps of selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the
15 largest value of the color distances of the selected pixels as the maximum color distance within the peer group, and performing color quantization by weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within the peer group.

- Alternatively, after the step (b-5), the method may further include the steps
20 of selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group, and obtaining the average of $T(n)$ values of the

whole image and performing color quantization using a value obtained by multiplying the average with a predetermined constant as the number of clusters, wherein $T(n)$ is the maximum color distance within the peer group.

Also, after the step (b-5), the method may further include the steps of
 5 selecting pixels whose number corresponds to the size of the peer group, ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group, and weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$
 10 is the maximum color distance within the peer group, and performing color quantization using a value obtained by multiplying the average of the $T(n)$ values of the whole image with a predetermined constant as the number of clusters.

The step (c) preferably includes replacing the central pixel $X_0(n)$ with a new pixel $X'_0(n)$ by the following Expression:

$$X'_0(m) = \frac{\sum_{i=0}^{m(n)-1} W_i p_i(n)}{\sum_{i=0}^{m(n)-1} W_i}$$

15

where $p_i(n)$ are the pixels constituting the peer group and W_i are predetermined weights corresponding to $p_i(n)$.

Also, the step (c) preferably includes replacing the color vector of the central
 20 pixel with an average weighted by a predetermined weight that is larger for a pixel closer to the central pixel and is smaller for a pixel distant from the central pixel.

The predetermined weight is preferably a value determined by a standard Gaussian function.

The color image processing method may further include the step of
 25 performing color quantization by weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within one group.

According to another aspect of the present invention, there is provided a color

image processing method including the steps of (a) receiving a color image frame and segmenting the same into a plurality of color images by a predetermined segmentation method. (b) sorting image pixels according to the color distance between the image pixels and a central pixel, with respect to an image selected
5 among the segmented color images, (c) grouping the sorted pixels into groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum, and (d) performing filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.

10 According to still another aspect of the present invention, there is provided a color image processing method including the steps of (a) defining a window having a predetermined size within an input color image. (b) selecting pixels having a color vector similar to that of the central pixel within the window and defining the selected pixels as a group. and (c) performing filtering of blurring using only the pixels
15 within the defined group.

The present invention is also embodied by a computer readable medium having program codes executable by a computer to perform a color image processing method. the method including the steps of (a) defining a window having a predetermined size within an input color image. (b) sorting image pixels according
20 to the color distance between the image pixels and a central pixel. (c) grouping the sorted pixels into groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum, and (d) performing filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.

25 Alternatively, the present invention provides a color image processing apparatus including sorting means for setting a window of a predetermined size within an input color image and sorting image pixels in the window according to the color distance between the image pixels and a central pixel, grouping means for grouping the sorted pixels into groups in which the difference in the intragroup color
30 distance is minimum and the difference in the intergroup color difference is maximum, and filtering means for performing filtering by replacing a central pixel

value with a predetermined pixel value determined by pixel values of pixels in the groups.

5 Brief Description of the Drawings

The above objects and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIGS. 1A and 1B are flow diagrams showing a color image processing
10 method according to the present invention; and

FIG. 2 is a block diagram of a color image processing apparatus according to the present invention.

15 Best mode for carrying out the Invention

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

Referring to FIG. 1A illustrating a color image processing method according to the present invention, a color image is input (step 100). The color image may be
20 in one region selected among image regions segmented by an appropriate segmentation method.

Next, with respect to color vectors of all pixels in a $L \times L$ window in an input color image, the color distance $d_i(n)$ from the color vector $X_0(n)$ of a pixel positioned at a position n at the center of the $L \times L$ window is represented by Expression (1) (step
25 102):

$$Distance(X_i(n), X_0(n)) \dots\dots(1)$$

wherein L is an arbitrary positive integer, and assuming that $K = L^2 - 1$, i is an integer from 0 through K . Also, for convenience' sake of explanation, $X_0(n)$, which represents the color vector of a pixel positioned at a position n at the center of the
30 $L \times L$ window in an input color image, may be used to represent the corresponding pixel positioned at the center, that is a central pixel.

Next, the corresponding color vectors of all pixels in the window are sorted in an ascending order according to the magnitude of the color distance $d_i(n)$ (step 104). Hereinbelow, the color vectors sorted in ascending order will be represented by $X_i(n)$.

- 5 Now, with respect to the color vectors sorted in ascending order, color distance difference is calculated by Expression (2) (step 106):

$$f_i(n) = d_{i-1}(n) - d_i(n) \dots\dots(2)$$

- and then color vectors in which $f_i(n)$ is greater than a predetermined threshold Q are removed (step 108). That is, the color vectors in which $f_i(n)$ is greater than a predetermined threshold Q are considered impulse noise to then be removed. According to experimental confirmation, it is more preferably to perform the step 108 with respect to the beginning $L/2$ pixels and the latter $L/2$ pixels in ascending order, than to perform it with respect to all the $(L^2 - 1)$ pixels in the $L \times L$ window, except of the central pixel $X_0(n)$.

- 15 Also, according to the present invention, in order to prevent edge blurring of an image, filtering is performed on pixels in a peer group to be described later, rather than on all the pixels in the $L \times L$ window. The peer groups are obtained as follows.

- First, the pixels sorted in ascending order according to their color distance from the color vector of the central pixel are divided into two groups. The first group consists of 0th through $(i-1)$ th pixels, and the second group consists of i th through K th pixels.

- Next, the average of the color distance differences for pixels of the first group and the average of the color distance differences for pixels of the second group are obtained as represented by Expressions (3a) and (3b), respectively:

$$a_1(i) = \frac{1}{i} \sum_{j=0}^{i-1} d_j(n) \dots\dots(3a)$$

$$a_2(i) = \frac{1}{K + 1 - i} \sum_{j=i}^K d_j(n) \dots\dots(3b)$$

and the variance of the color distance differences for pixels of the first group and the variance of the color distance difference for pixels of the second group are obtained as represented by Expressions (3c) and (3d), respectively:

$$S_1^2(i) = \sum_{j=0}^{i-1} |d_j(n) - a_1(i)|^2 \quad \dots\dots(3c)$$

$$S_2^2(i) = \sum_{j=i}^K |d_j(n) - a_2(i)|^2 \quad \dots\dots(3d)$$

wherein i is a newly defined integer ranging from 0 through K .

Then, using the obtained average and variance, a value $J(i)$ represented by Expression (4) is calculated (step 110):

$$J(i) = \frac{|a_1(i) - a_2(i)|^2}{s_1^2(i) + s_2^2(i)} \quad \dots\dots(4)$$

10 wherein i is an integer ranging from 1 through K . The Expression (4) is based on Fisher's discriminant estimation method.

Here, the actual range of i is from 1 through the numbers obtained by subtracting the number corresponding to color vectors of the pixels considered as impulse noise for removal from K . However, since the number corresponding to
15 color vectors of the pixels considered as impulse noise and removed is not so large, it is assumed that the range of i is from 1 through K .

Next, the value of i which makes $J(i)$ maximum is obtained by Expression (5):

$$m(n) = \underset{i}{\arg \max} \{J(i)\} \quad \dots\dots(5)$$

20 to then determine the obtained value of i as the magnitude of a peer group $P(n)$ (step 112). In other words, when i is reset to variables ranging from 0 through the value obtained in the step 112, the peer group $P(n)$ consists of pixels $p_i(n)$.

Referring to FIG. 1B, the central pixel $X_n(n)$ is replaced with a new pixel

$X'_0(n)$ by Expression (6):

$$X'_0(m) = \frac{\sum_{i=0}^{m(n)-1} W_i p_i(n)}{\sum_{i=0}^{m(n)-1} W_i} \dots\dots(6)$$

where W_i are the standard Gaussian weights corresponding to $p_i(n)$ (step 114). Here, the standard Gaussian weights W_i are determined by a standard Gaussian function.

5 A pixel closer to the center of an image has a larger standard Gaussian weight and a pixel distant from the center has a smaller standard Gaussian weight. The procedure of replacing pixels in such a manner is smoothing or filtering.

Supposing the maximum color distance in each peer group $d_{m(n)-1}(n)$ is $T(n)$. $\exp(-T(n))$ is applied to the color vectors of the respective pixels during color

10 quantization (step 116). The maximum color distance $d_{m(n)-1}(n)$ in each peer group indicates the largest value of the color distances of pixels whose number correspond to the size of the peer group ranging from the pixel having the minimum color distance, among the pixels sorted in ascending order according to their color distance from the central pixel. Thus, the smaller the maximum color distance $d_{m(n)-1}(n)$ in

15 each peer group, the shorter the color distance from the central pixel, so that $d_{m(n)-1}(n)$ is an indicator of the smoothness of an image. Also, since $\exp(-T(n))$ is weighted to the color vectors of the respective pixels, the pixels in smooth regions are more heavily weighted than the pixels in highly noisy regions. Weighting the pixels in highly noisy regions more lightly than the pixels in the smooth regions is

20 based on the analysis result of eye-perception, that is, the eye-perception is more sensitive to changes in detailed regions than in smooth regions.

According to the present invention, during quantization, the value obtained by multiplying a predetermined constant with the average of $T(n)$ values of all images is preferably used as the number of clusters. In other words, during

25 quantization, fewer clusters are used in smooth regions where the $T(n)$ value is small, and more clusters are used in highly noisy regions where the $T(n)$ value is large.

In the color image processing method according to the present invention, only the pixels having large color distances from the central pixel are removed, and then a peer group having a color vector similar to that of the central pixel is defined to then perform filtering thereon. Thus, edge blurring of an image rarely occurs due to removal and filtering of impulse noise. Also, according to the present invention, the information on the extent of quantization to be performed on an image can be obtained.

The color image processing method is programmable by a computer program. Codes and code segments constituting the computer program can be easily derived by a computer programmer in the art. Also, the program is stored in computer readable media and is readable and executable by the computer, thereby embodying the color image processing method. The media include magnetic recording media, optical recording media, carrier wave media, and the like.

Also, the color image processing method can be implemented on a color image processing apparatus. FIG. 2 is a block diagram of a color image processing apparatus according to the present invention. Referring to FIG. 2, the color image processing apparatus according to the present invention includes a segmenting unit 200, a sorting unit 202, an impulse noise removing unit 204, a grouping unit 206, a filtering unit 208 and a quantizing unit 210.

In the operation of the color image processing apparatus, the segmenting unit 200 receives a color image frame and segments the color image frame into a plurality of color images by a predetermined segmentation method.

The sorting unit 202 sets an $L \times L$ window (L is a predetermined positive integer.) within the color images, and sorts the pixels within the window according to the color distance between each pixel and the central pixel. Thus, the sorting unit 202 outputs color vectors of the sorted pixels.

The impulse noise removing unit 204 removes the pixels that have a difference in color distance from the central pixel greater than a predetermined threshold, with respect to the beginning $L/2$ pixels and the latter $L/2$ pixels among the sorted pixels.

The grouping unit 206 receives color vectors of all the noise-removed pixels

in the $L \times L$ window and divides the same into two groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum, by calculating the function represented by the Expression (4) using the variance and average of the color distances between the sorted pixels.

- 5 The filtering unit 208 performs filtering by replacing the central pixels with pixels in a group having a small difference from the color vector of the central pixels in the window.

 The quantizing unit 210 weights the color vectors of the respective pixels by $\exp(-T(n))$, in which $T(n)$ is the maximum color distance within a group having a
10 small difference in the color vector from the central pixel within the window, and performs quantization using the value obtained by multiplying a predetermined constant with the average of $T(n)$ values of all images as the number of clusters.

 In the above-described color image processing apparatus according to the present invention, since the pixels having large color distances from the central pixel
15 are removed, a peer group having a color vector similar to that of the central pixel is defined to then perform filtering thereon. Thus, edge blurring of an image rarely occurs due to removal and filtering of impulse noise. Also, according to the present invention, the information on the number of clusters for quantization to be performed can be obtained based on the smoothness or details of an image to be
20 processed. Thus, quantization is can be effectively performed using the information.

 As described above, according to the present invention, in removing impulse noise from an image and filtering the same, the generation of edge blurring of the image can be reduced.

25

Industrial Applicability

 The present invention can be applied to the fields of color image indexing or searching applications.

What is claimed is:

1. A color image processing method comprising the steps of:
 - (a) sorting image pixels according to the color distance between the image pixels and a central pixel;
 - 5 (b) grouping the sorted pixels into groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum; and
 - (c) performing filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.
- 10 2. The color image processing method according to claim 1, further comprising the step of defining a window having a predetermined size within an input color image, wherein the image pixels are pixels within the window.
- 15 3. The color image processing method according to claim 1, before the step (b), further comprising the step of removing pixels having a difference in color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.
- 20 4. The color image processing method according to claim 3, wherein the predetermined number is less than or equal to $L/2$, in which L is a predetermined positive integer indicating the size of an $L \times L$ window.
- 25 5. The color image processing method according to claim 2, before the step (b), further comprising the step of removing pixels having a difference in color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.
- 30 6. The color image processing method according to any of claims 1

through 5, wherein the step (b) includes grouping the sorted pixels using a function based on a Fisher's discriminant estimation method.

7. The color image processing method according to claim 1, wherein the step (b) comprises the sub-steps of:

(b-1) setting a first group consisting of 0th through $(i-1)$ th pixels, and a second group consisting of i th through K th pixels, wherein i is an integer from 0 through K and $K=L^2-1$;

(b-2) obtaining the respective averages of the color distance differences for pixels of the first and second groups by the following Expressions:

$$a_1(i) = \frac{1}{i} \sum_{j=0}^{i-1} d_j(n) \quad \text{and} \quad a_2(i) = \frac{1}{K+1-i} \sum_{j=i}^K d_j(n)$$

(b-3) obtaining the respective variances of the color distance differences for pixels of the first and second groups are obtained by the following Expressions:

$$S_1^2(i) = \sum_{j=0}^{i-1} |d_j(n) - a_1(i)|^2 \quad \text{and} \quad S_2^2(i) = \sum_{j=i}^K |d_j(n) - a_2(i)|^2$$

(b-4) calculating a value $J(i)$ by the following Expression, using the obtained average and variance:

$$J(i) = \frac{|a_1(i) - a_2(i)|^2}{s_1^2(i) + s_2^2(i)} ; \text{ and}$$

(b-5) obtaining the value of i which makes $J(i)$ maximum by the following Expression:

$$m(n) = \underset{i}{\arg} \{ \max J(i) \}$$

and selecting pixels ranging from a pixel having a small color distance to a pixel having the obtained value of i to determine the same as a peer group $P(n)$.

8. The color image processing method according to claim 7, after the step (b-5), further comprising the steps of:

selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and
5 setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

performing color quantization by weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within the peer group.

10

9. The color image processing method according to claim 7, after the step (b-5), further comprising the steps of:

selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and
15 setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

obtaining the average of $T(n)$ values of the whole image and performing color quantization using a value obtained by multiplying the average with a predetermined constant as the number of clusters, wherein $T(n)$ is the maximum color distance
20 within the peer group.

10. The color image processing method according to claim 7, after the step (b-5), further comprising the steps of:

selecting pixels whose number corresponds to the size of the peer group,
25 ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein
30 $T(n)$ is the maximum color distance within the peer group, and performing color quantization using a value obtained by multiplying the average of the $T(n)$ values of

the whole image with a predetermined constant as the number of clusters.

11. The color image processing method according to claim 7, wherein the step (c) includes replacing the central pixel $X_0(n)$ with a new pixel $X'_0(n)$ by the following Expression:

$$X'_0(m) = \frac{\sum_{i=0}^{m(n)-1} W_i p_i(n)}{\sum_{i=0}^{m(n)-1} W_i}$$

where $p_i(n)$ are the pixels constituting the peer group and W_i are predetermined weights corresponding to $p_i(n)$.

12. The color image processing method according to claim 1, wherein the step (c) includes replacing the color vector of the central pixel with an average weighted by a predetermined weight that is larger for a pixel closer to the central pixel and is smaller for a pixel distant from the central pixel.

13. The color image processing method according to claim 12, wherein the predetermined weight is a value determined by a standard Gaussian function.

14. The color image processing method according to claim 1, further comprising the step of performing color quantization by weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within one group.

15. A color image processing method comprising the steps of:
- (a) receiving a color image frame and segmenting the same into a plurality of color images by a predetermined segmentation method;
 - (b) sorting image pixels according to the color distance between the image pixels and a central pixel, with respect to an image selected among the segmented

color images;

(c) grouping the sorted pixels into groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum; and

- 5 (d) performing filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.

16. The color image processing method according to claim 15, before the step (b), further comprising the step of defining a window having a predetermined
10 size within the selected color image, wherein the image pixels are pixels within the window.

17. The color image processing method according to claim 15, before the step (b), further comprising the step of removing pixels having a difference in the
15 color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.

18. The color image processing method according to claim 17, wherein
20 the predetermined number is less than or equal to $L/2$, in which L is a predetermined positive integer indicating the size of an $L \times L$ window.

19. The color image processing method according to claim 15, before the step (b), further comprising the step of removing pixels having a difference in color
25 distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.

20. The color image processing method according to any of claims 15
30 through 19, wherein the step (b) includes grouping the sorted pixels using a function based on a Fisher's discriminant estimation method.

21. The color image processing method according to claim 15, wherein the step (b) comprises the sub-steps of:

(b-1) setting a first group consisting of 0th through $(i-1)$ th pixels, and a second group consisting of i th through K th pixels, wherein i is an integer from 0
5 through K and $K=L^2-1$;

(b-2) obtaining the respective averages of the color distance differences for pixels of the first and second groups by the following Expressions:

$$a_1(i) = \frac{1}{i} \sum_{j=0}^{i-1} d_j(n) \quad \text{and} \quad a_2(i) = \frac{1}{K+1-i} \sum_{j=i}^K d_j(n) ;$$

(b-3) obtaining the respective variances of the color distance differences for
10 pixels of the first and second groups are obtained by the following Expressions:

$$S_1^2(i) = \sum_{j=0}^{i-1} |d_j(n) - a_1(i)|^2 \quad \text{and} \quad S_2^2(i) = \sum_{j=i}^K |d_j(n) - a_2(i)|^2 ;$$

(b-4) calculating a value $J(i)$ by the following Expression, using the obtained average and variance:

$$J(i) = \frac{|a_1(i) - a_2(i)|^2}{S_1^2(i) + S_2^2(i)} ; \text{ and}$$

15 (b-5) obtaining the value of i which makes $J(i)$ maximum by the following Expression:

$$m(n) = \arg \max_i \{J(i)\}$$

and selecting pixels ranging from a pixel having a small color distance to a pixel having the obtained value of i to be determined as a peer group $P(n)$.

22. The color image processing method according to claim 15, wherein the step (c) includes replacing the color vector of the central pixel with an average weighted by a predetermined weight that is larger for a pixel closer to the central

pixel and is smaller for a pixel distant from the central pixel.

23. The color image processing method according to claim 22, wherein the predetermined weight is a value determined by a standard Gaussian function.

5

24. The color image processing method according to claim 15, wherein the step (c) includes replacing the central pixel $X_0(n)$ with a new pixel $X'_0(n)$ by the following Expression:

$$X'_0(m) = \frac{\sum_{i=0}^{m(n)-1} W_i p_i(n)}{\sum_{i=0}^{m(n)-1} W_i}$$

10 where $p_i(n)$ are the pixels constituting the peer group and W are predetermined weights corresponding to $p_i(n)$.

25. The color image processing method according to claim 21, after the step (b-5), further comprising the steps of:

15 selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

performing color quantization by weighting the color vectors of the respective
20 pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within the peer group.

26. The color image processing method according to claim 21, after the step (b-5), further comprising the steps of:

25 selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum

color distance within the peer group; and

obtaining the average of $T(n)$ values of the whole image and performing color quantization using a value obtained by multiplying the average with a predetermined constant as the number of clusters.

5

27. The color image processing method according to claim 19, after the step (b-5), further comprising the steps of:

selecting pixels whose number corresponds to the size of the peer group, ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within the peer group, and performing color quantization using a value obtained by multiplying the average of the $T(n)$ values of the whole image with a predetermined constant as the number of clusters.

28. The color image processing method according to claim 24, after the step (b-5), further comprising the steps of:

20 selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

obtaining the average of $T(n)$ values of the whole image and performing color quantization using a value obtained by multiplying the average with a predetermined constant as the number of clusters.

29. The color image processing method according to claim 24, after the step (b-5), further comprising the steps of:

30 selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and

setting the largest value of the color distances of the selected pixels as the maximum color distance within the peer group; and

- obtaining the average of $T(n)$ values of the whole image and performing color quantization using a value obtained by multiplying the average with a predetermined
5 constant as the number of clusters.

30. A color image processing method comprising the steps of:

- (a) defining a window having a predetermined size within an input color
image;
10 (b) selecting pixels having a color vector similar to that of the central pixel within the window and defining the selected pixels as a group; and
(c) performing filtering of blurring using only the pixels within the defined group.

- 15 31. A computer readable medium having program codes executable by a computer to perform a color image processing method, the method comprising the steps of:

- (a) defining a window having a predetermined size within an input color
image;
20 (b) sorting image pixels according to the color distance between the image pixels and a central pixel;
(c) grouping the sorted pixels into groups in which the difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum; and
25 (d) performing filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.

32. The computer readable medium according to claim 31, wherein before the step (c), the color image processing method further comprises the step of
30 removing pixels having a difference in the color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined

number of pixels at the beginning and latter parts among the sorted pixels.

33. The computer readable medium according to claim 31, wherein the color image processing method further comprises the steps of:

- 5 selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the selected group; and
- 10 performing color quantization by weighting the color vectors of the respective pixels $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within the peer group.

34. The computer readable medium according to claim 31, wherein the color image processing method further comprises the steps of:

- 15 selecting i pixels ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the selected group; and
- 20 obtaining the average of $T(n)$ values of the whole image and performing color quantization using a value obtained by multiplying the average with a predetermined constant as the number of clusters.

35. The computer readable medium according to claim 31, wherein the color image processing method further comprises the steps of:

- 25 selecting pixels whose number corresponds to the size of the peer group, ranging from the pixel having the minimum color distance among the pixels sorted according to the color distance from the central pixel and setting the largest value of the color distances of the selected pixels as the maximum color distance within the selected group; and
- 30 weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within the selected group, and performing color

quantization using a value obtained by multiplying the average of the $T(n)$ values of the whole image with a predetermined constant as the number of clusters.

36. The computer readable medium according to claim 31, wherein the
5 color image processing method further comprises the step of receiving a color image frame and segmenting the same into a plurality of color images by a predetermined segmentation method, wherein the color image is an image selected from the plurality of color images.

10 37. A color image processing apparatus comprising:
sorting means for setting a window of a predetermined size within an input color image and sorting image pixels in the window according to the color distance between the image pixels and a central pixel;
grouping means for grouping the sorted pixels into groups in which the
15 difference in the intragroup color distance is minimum and the difference in the intergroup color difference is maximum; and
filtering means for performing filtering by replacing a central pixel value with a predetermined pixel value determined by pixel values of pixels in the groups.

20 38. The color image processing apparatus according to claim 37, further comprising quantizing means for performing color quantization by weighting the color vectors of the respective pixels by $\exp(-T(n))$, wherein $T(n)$ is the maximum color distance within a group having the smallest difference in the color vector from the central pixel within the window.

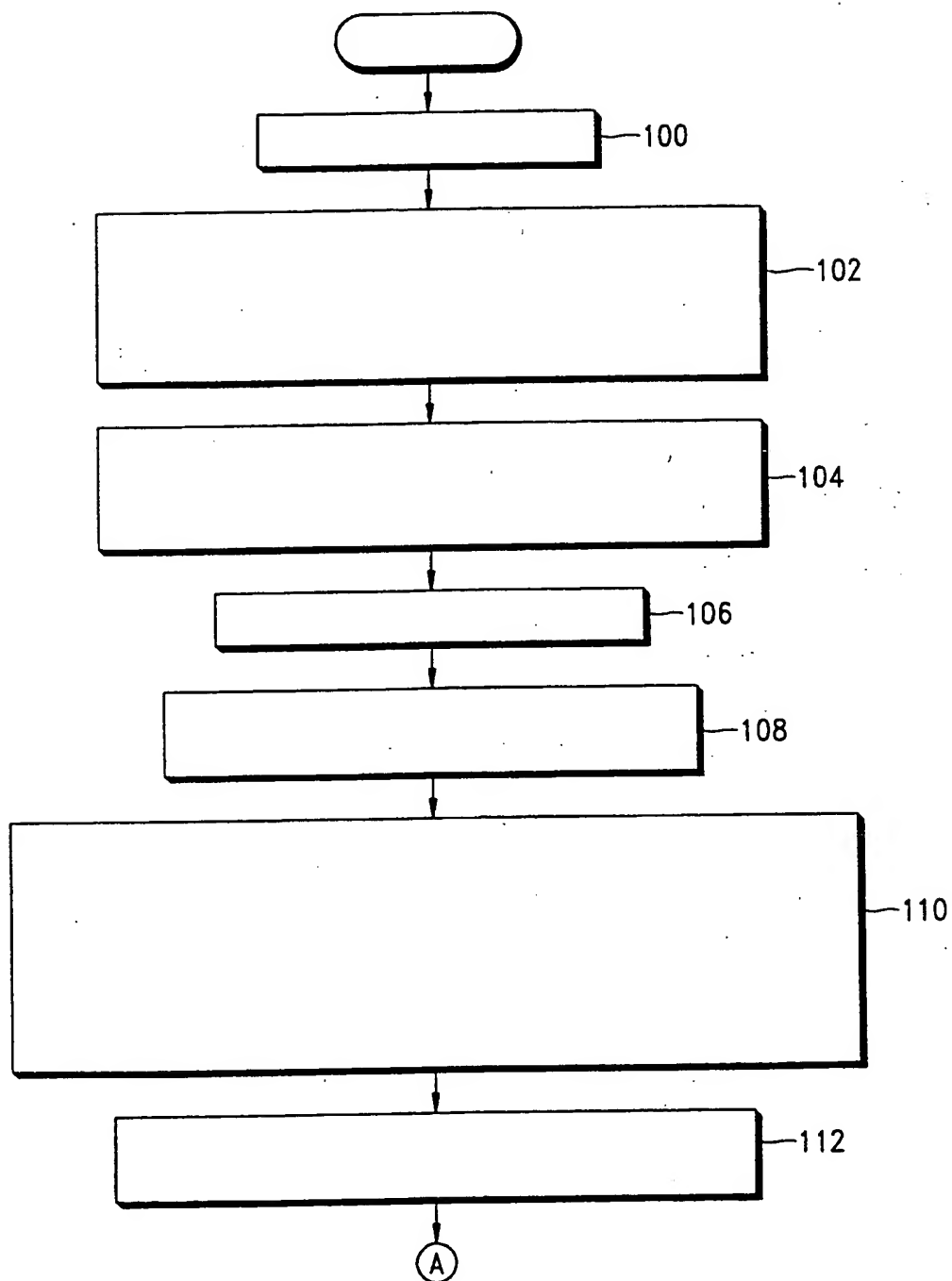
25 39. The color image processing apparatus according to claim 37, further comprising quantizing means for obtaining the average of $T(n)$ values of the whole image and performing color quantization using a value obtained by multiplying the average with a predetermined constant as the number of clusters, wherein $T(n)$ is the
30 maximum color distance within a group having the smallest difference in the color vector from the central pixel within the window.

40. The color image processing apparatus according to claim 37, further comprising quantizing means for weighting the color vectors of the respective pixels by $\exp(-T(n))$, and performing color quantization using a value obtained by multiplying the average of $T(n)$ values of the whole image with a predetermined constant as the number of clusters, wherein $T(n)$ is the maximum color distance within a group having the smallest difference in the color vector from the central pixel within the window.

41. The color image processing apparatus according to claim 37, further comprising impulse noise removing means for removing pixels having a difference in the color distance from the central pixel greater than or equal to a predetermined threshold, with respect to a predetermined number of pixels at the beginning and latter parts among the sorted pixels.

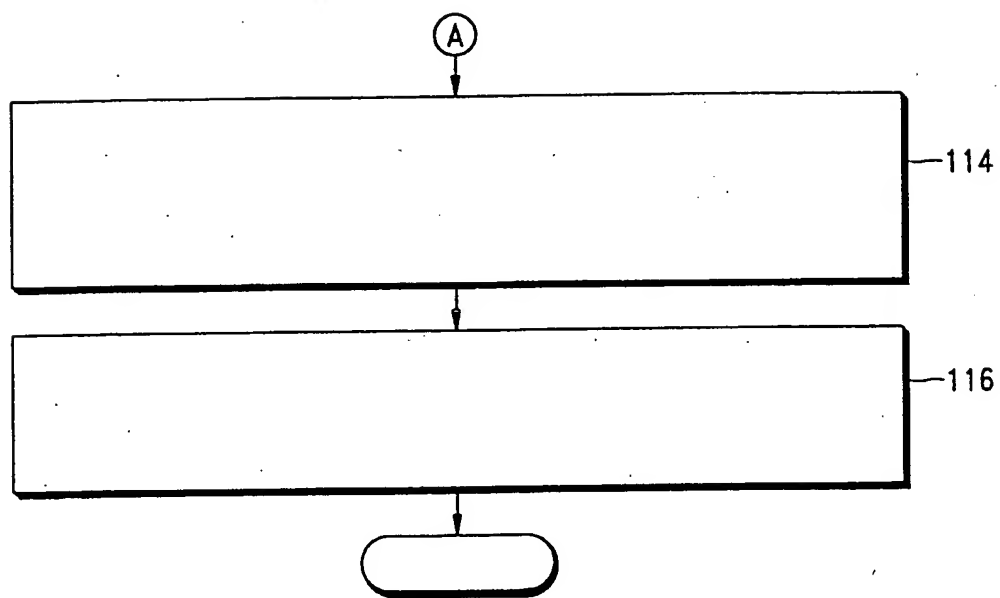
42. The color image processing apparatus according to claim 37, further comprising segmenting means for receiving a color image frame and segmenting the same into a plurality of color images by a predetermined segmentation method, wherein the color image is an image selected from the plurality of color images.

1/3
FIG. 1A



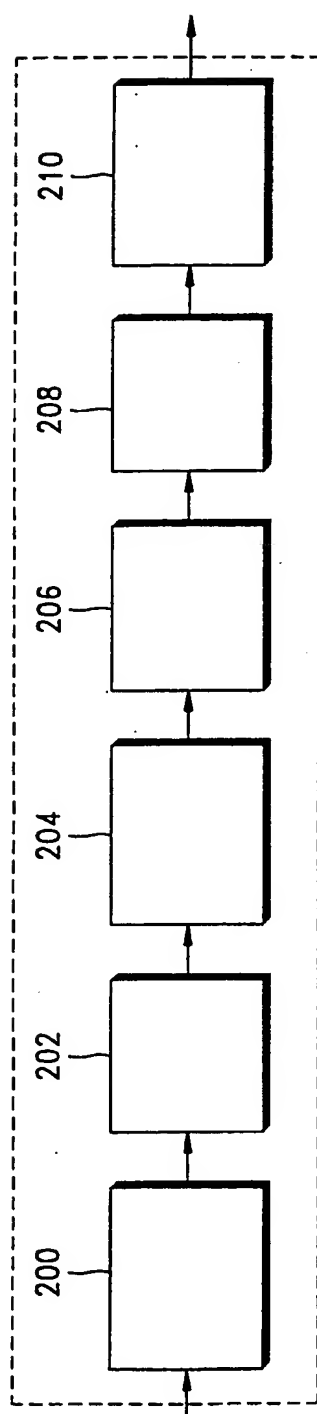
2/3

FIG. 1B



3/3

FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR00/00090

A. CLASSIFICATION OF SUBJECT MATTER .

IPC7 G06T 1/00, G06T 7/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 G06T1/00, G06T7/60

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean patents and applications for inventions since 1975

Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ, IEEE/IEE Electronic Library (Since 1988) "COLOR", "SEGMENT", "GROUPING", "IMAGE"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Content-Based Access of Image and Video Libraries, 1998. Proceedings. IEEE Workshop on Published: 1998, Page(s): 3 -8 Vailaya, A.; Jain, A.; Hong Jiang Zhang "On image classification: city vs. landscape"	1-3, 15, 16, 30, 37
Y	Image Processing, 1996. Proceedings., International Conference on Published: 1996 Volume: 1, Page(s): 761 -764 vol.2 Malik, J.; Forsyth, D.A.; Fleck, M.M.; Greenspan, H.; Leung, T.; Carson, C.; Belongie, S.; Bregler, C. "Finding objects in image databases by grouping"	1-3, 15, 16, 30, 37
A	Signals, Systems and Computers, 1988. Twenty-Second Asilomar Conference on Published: 1988 Volume: 1, Page(s): 305 -309 Khotanzad, A.; Bouarfa, A. "A Parallel, Non-parametric, Non-iterative Clustering Algorithm With Application To Image Segmentation"	1-42
A	EP 0522702 A (HEWLETT-PACKARD CO.) 13 January 1993 (13. 01. 1993) The whole document	1, 15, 30, 37

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

15 MAY 2000 (15.05.2000)

Date of mailing of the international search report

18 MAY 2000 (18.05.2000)

Name and mailing address of the ISA/KR

Korean Industrial Property Office
Government Complex-Taejon, Dunsan-dong, So-ku, Taejon
Metropolitan City 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LEE, Jung Suk

Telephone No. 82-42-481-5789

